DENTAL ANÆSTHETICS

W. E. ALDERSON, M.D.

SECOND EDITION

DENTAL ANÆSTHETICS

A TEXT-BOOK FOR STUDENTS AND PRACTITIONERS

WITH A CONTRIBUTION ON ANALGESIA

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TO

J. T. JAMESON, Esq., L.D.S. Ed.

DEAN OF THE NEWCASTLE-UPON-TYNE

DENTAL HOSPITAL AND SCHOOL.

PREFACE TO THE SECOND EDITION.

For this edition the whole text has been thoroughly revised, and Chapter IV. amplified by the insertion of new paragraphs dealing with the continuous administration of nitrous oxide, and the simultaneous exhibition of nitrous oxide and oxygen.

November, 1912. W. E. A.

PREFACE TO THE FIRST EDITION.

At the request of past and present students of the Newcastle-upon-Tyne Dental Hospital and School, I offer herewith, in the form of a short text-book, a resumé of my Lectures on Dental Anæsthetics, in the hope that it may prove of value to Students generally in preparing for examination, and to Practitioners interested in the administration of dental anæsthetics.

In order to present this little work in a concise and economical form, I have omitted illustrations of apparatuses, relying upon brief descriptions of those in more common use to make their application understood.

Since a text-book on Dental Anæsthetics would be incomplete without a description of Analgesia, I have arranged with Mr. John Bolam, L.D.S., Honorary Assistant Surgeon and Lecturer on Materia Medica and Therapeutics, Newcastle-upon-Tyne Dental Hospital and School, to contribute an article upon this subject.

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28, Victoria Square,
Newcastle-upon-Tyne, 1911.

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DENTAL ANÆSTHETICS

CHAPTER I.

ANÆSTHESIA.

"ANÆSTHESIA" is the name suggested by Oliver Wendell Holmes in a letter to William T. G. Morton, to describe the condition produced in the individual by the inhalation of sulphuric ether.

The word anæsthesia means "Insensibility —more especially to objects of touch," and although almost a misnomer in the present state of our practice, well expressed in the early days of discovery that which it was intended to convey.

Between the anæsthesia as produced by its pioneers, and anæsthesia as we now see it induced daily, there is a wide gulf of difference. All that was attempted then was to obtain a condition during which the pain inflicted would not afterwards be remembered by the patient. There was no thought of continuous administration; no limitation of movements; sufficient only of the agent was given to stupefy the

patient ; at this stage it was discontinued, and the operation rapidly performed, the cries and movements of the patient being looked upon as a necessary evil and an unpreventable accompaniment.

Nowadays, in inducing anæsthesia we can with confidence guarantee a state of complete general insensibility, varying in duration with the necessities of the operation. Not only will consciousness be abolished, but motor and reflex acts will be in abeyance. The exact intrinsic nature of anæsthesia and its mode of production is still undecided. We can but point in passing to its resemblance to sleep, natural and induced, and suggest that an elucidation of the latter state will open up a path to the solution of the question.

Anæsthesia is sub-divided into two classes :—

(1) *General Anæsthesia* ; (2) *Local Anæsthesia.*

(1.) **General Anæsthesia** corresponds to the condition alluded to above, and results from the introduction into the system, by inhalation, of a drug capable of producing the required state.

(2.) **Local Anæsthesia** is a temporary paralysis of certain sensory nerve endings obtained (*a*) by the direct action of certain drugs in solution, either applied directly to the surface (as in the case of the cornea), or introduced

below the surface (as in the case of the gums) ; (*b*) by freezing of the required area.

For the sake of clearness it is preferable to speak of local anæsthesia as *Analgesia* (insensibility to pain), and to reserve for the term anæsthesia—without the qualifying word general—the meaning it was originally intended to convey.

PHYSIOLOGY OF ANÆSTHESIA.

The state of anæsthesia, by whatever means induced, is always fundamentally of the same nature. Differences of degree, and of rapidity of induction are met with, depending upon the special potency of the agent employed ; differences of symptomatic interest result from the variations in the action of the drugs used, apart from their special action as anæsthetics ; differences in toxicity exist, due to either the varying fatal dose of the different agents, or their direct effect upon tissue substance.

Nevertheless, and this fact must be firmly grasped if we are to understand the action of anæsthetics and employ them intelligently, the mode of production of the state of anæsthesia is always the same.

The drug, either in the form of a gas or a vapour, is inspired with the tidal and complemental air, and permeates the reserve and residual air in the lung alveoli. Then, following

the law of diffusion of gases, it enters the blood stream through the walls of the pulmonary capillaries, and is carried to the brain, where it exerts its specific action. The resulting anæsthesia is in proportion to the accumulation of the drug in the blood stream, a return to consciousness commencing directly the inhalation is discontinued. Elimination of the anæsthetic is rapidly accomplished by expiration, although with some drugs a certain amount of remote excretion occurs.

GENERAL PHENOMENA OF ANÆSTHESIA.

It is usual, in describing the effects seen in the individual by the administration of a drug capable of producing anæsthesia, to classify the symptoms in stages.

This system, while of advantage to the beginner as a means of understanding the sequence of events, is at the best an arbitrary classification and apt to be misleading. Particularly is this so in the case of dental students, who rarely see an anæsthetic administration sufficiently prolonged to allow of the stages being clearly differentiated.

Indeed, it is not till anæsthesia has been induced for some fifteen to twenty minutes that this is possible. I refer of course to those drugs which are slow in action and capable of being administered for long periods. In the case of

drugs which take effect rapidly, and are respirable only for a brief time, differentiation into stages is well-nigh impossible, and serves no useful purpose.

Let us therefore grasp this fact at the outset :—the so-called "stages" refer to the degree of anæsthesia existing at a given time, and not necessarily to the progressive depth reached in the stage of induction. To make this point clear, I will avoid the word "stage" as applied in this sense, and adopt "phase" in its stead. (Gr., φάσις—an appearance.)

For purposes of demonstration I prefer to recognize three "phases," taking care always to point out that overlapping occurs, since all centres are rarely affected to the same degree at the same time.

The very essence of the existence of anæsthesia ; the feasibility of its employment in surgical work ; and the comparative safety of the individual while under the influence of the drug employed to produce it, depend upon the following facts :—

1. The effects produced upon the nerve centres occur in definite order—the highest (or mental) centres being first attacked, the lowest (or vital) being the most resistant and the last to succumb.

2. Recovery commences directly the inhalation is discontinued, and takes place in the

reverse order, the lowest centres being the first, the highest centres the last, to reach the *status quo ante*.

3. Reflex action, which would be exaggerated in the absence of normal voluntary inhibition, and so become liable to cause inconvenience to the operator and danger to the patient, can be held in check by the anæsthetist and, if necessary, abolished.

In the return to consciousness, lucid intervals occur, separated by periods of unconsciousness. This is of importance in influencing our demeanour in the recovery room, where all talking and remarks upon the case should be avoided.

SPECIAL PHENOMENA OF ANÆSTHESIA.

As indicated in the following table, certain special indications exist as to the phase of anæsthesia present at a given stage. These I propose to discuss more fully here.

A. The Eye.

1. *The Globes*.—These as a rule are mobile, except under very deep anæsthesia.

2. *The Pupils*.—The size and activity of the pupils constitute one of the most important guides as to the degree of anæsthesia present. Fallacies may easily occur, however, if attention to the following points be disregarded :—

i. The size of each pupil should be noted previous to the administration.

PHASES OF ANÆSTHESIA.

	Physiological Effect.	Signs and Symptoms during Induction.	Signs during Anæsthesia.
Primary Phase.	Stimulation	Confused and grandiose ideas. Shouting. Laughing. Singing. Crying. Noises in the ears. Flashes of light. Muscular movements—purposive and erratic. Increase of force and rate of pulse. Hyperpnœa. Dyspnœa. Corneal reflex present.	Movements. Moaning, crying, and other hysterical manifestations. Retching or vomiting. Pupils dilated and active. Globes mobile. Corneal reflex present.
Intermediate Phase.	Depression	Loss of sensibility. Muscular relaxation. Diminished volume of pulse. Stertorous breathing. Corneal reflex disappearing.	Pupils contracted and active. Globes mobile. Corneal reflex returning.
Ultimate Phase.	Reflex paralysis	Total loss of all reflex excitability. Thin pulse. Faint respiration. Corneal reflex absent.	Pupils dilated and inactive. Globes fixed. Corneal reflex absent.

Surgical anæsthesia usually exists towards the end of the Intermediate and the beginning of the Ultimate Phases.

ii. The effects produced must be watched in both pupils.

iii. Alterations in size result from causes other than anæsthesia.

iv. Variations in size in relation to the depth of anæsthesia present are not constant till the administration has been continued for at least fifteen minutes.

v. Effects vary with the drug employed.

The diameter of the intra-sclerotic circle is usually about 8 mm., and this measurement is nearly obtained by the instillation of atropine. The contracted pupil of opium poisoning has as small a diameter as ·5 mm. Between these extremes there is a wide range: an average pupil in ordinary daylight measures 2 to 3 mm. in diameter; anything above that constitutes a dilated pupil, anything below, a contracted pupil.

A normal pupil equals its fellow in size, and contracts in a bright light and when accommodating for a near object. *Inequality* results from (*a*) central or peripheral nervous conditions; (*b*) old iritis. *Absence of light reflex* results from (*a*) locomotor ataxia (Argyll Robertson pupil); (*b*) adhesions due to disease. *Failure to react for accommodation* may result from adhesions.

A markedly contracted pupil is present in general paralysis of the insane.

In the anæsthetic state the pupil varies in size and activity in a manner sufficiently constant to admit of its use as an index of the depth of anæsthesia.

The Primary Phase is characterized by dilatation, due to stimulation of the sympathetic nerves of the radiating fibres of the iris.

The Intermediate Phase shows a contracted pupil, due to the action of the circular fibres of the iris, through stimulation of the third nerve.

In the Ultimate Phase the pupil is dilated and inactive as the result of nerve paralysis, fixation of the globes occurring from the same cause.

Since these phenomena are best seen after fifteen to twenty minutes' administration, it is obvious that we must not look for them in nitrous oxide anæsthesia—a gradual dilatation (in direct relation to the amount of anoxæmia present) being the rule with this drug.

The pupil in chloroform (surgical) anæsthesia is smaller and less active than in ether (surgical) anæsthesia, the difference however being less evident with open ether than when the closed system is employed. Reflex dilatation from surgical procedures is apt to occur, especially during light anæsthesia, and must be borne in mind.

3. *Lid-reflex.*—In gauging the depth of anæsthesia and the progress of the administration, no more valuable sign exists than the

instinctive closure of the lids when a foreign body approaches the eyeball.

Two reflexes are described, (*a*) the conjunctival, and (*b*) the corneal.

The former is of little value, and its abolition is not necessarily a sign of deep anæsthesia. The latter is a delicate test, since its presence must always denote either incomplete administration or returning consciousness. This applies chiefly to ether and chloroform. In nitrous oxide anæsthesia a satisfactory result can be obtained without its abolition.

We must remember that the cornea rapidly loses its exquisite sensitiveness with frequent contact, so that the test may prove fallacious if repeatedly made on one eye only.

B. Respiration

1. *Hyperpnœa* (increased respiratory effort) is met with in the Primary Phase, and may be due to (*a*) anxiety and nervousness on the part of the patient; (*b*) stimulation of the respiratory centre.

2. *Apnœa* (temporary cessation of respiration) may result from excessive hyperpnœa.

3. *Dyspnœa* (embarrassed respiration) is usually associated with obstruction of the upper air-passages from asphyxia, excess of secretion, swelling of parts, or muscular spasm.

4. *Adventitious sounds*: (i) *Expiratory*—

phonation ; (ii) *Inspiratory*—stertor or snoring sound ; stridor or creaking sound.

i. Phonation always denotes a moderate degree of anæsthesia.

ii. *Stertor* may result from :—

a. Faulty posture.

b. Muscular spasm or paralysis.

c. Swelling of parts.

d. Excess of secretion.

And is supra-laryngeal in origin.

Stridor is either :—

a. High-pitched, due to laryngeal spasm ; or

b. Deep and harsh, due to collapse of vocal cords.

Whatever the cause, adventitious inspiratory sounds always indicate obstruction.

C. The Muscular System.

1. *Purposive Movements*.—In the Primary Phase, slight movements associated with the partially conscious and disturbed mental state are apt to be continued in a greatly exaggerated form.

2. *Tonic Contractions*.—Are usually met with just before surgical anæsthesia is obtained.

3. *Clonic Contractions*.—When limited to one limb are associated with, and can be controlled by, alteration of posture.

When general (jactitation), they are of interest as indicating the association of asphyxia.

CHAPTER II.

THE CHOICE OF AN ANÆSTHETIC.

Approaching this subject in its relation to dental surgery, a different outlook must be adopted from that indicated when general surgery is under discussion. Three main factors guide us in our selection, i.e., the point of view of the

1. Operator.
2. Anæsthetist.
3. Patient.

In general surgery all three points must be considered if a successful issue is to ensue.

In dental surgery, however, the main point to be considered is *the safety of the patient.* Two classes of operation are met with : (*a*) *The short operation*—single or easily performed multiple extractions, removal of the pulp ; and (*b*) *The long operation*—removal of impacted roots, multiple extractions necessitating a longer available anæsthesia than in (*a*), and treatment of antrum disease. In all cases, however, the operation is of the same nature —neither the operation nor the necessity for it involves danger to life, and in selecting the anæsthetic this fact must first influence our decision.

In comparing the relative safety of anæsthetic agents in dental surgery, we must do so on different lines from those used in computing general mortality percentages.

The death-rate from chloroform is stated to be 1 in 3000 cases—that from ether 1 in 18000 cases—so that ether is six times safer than chloroform.

Chloroform is apt to cause death during the stage of induction, and that in an obviously healthy person; ether is devoid of this risk.

Again, ether being a respiratory and circulatory stimulant, is usually chosen in those "last chance" operations of long duration where death occurs during the operation because the patient was *in extremis* from the start.

Moreover, the respiratory troubles (bronchitis, pneumonia) which are attributed rightly or wrongly to the exhibition of ether, are not met with after operations of short duration as in dental surgery. So in reality ether has for us a greater relative safety than would seem the case as shown by statistics.

Nitrous oxide is universally considered safe, but this very idea of safety constitutes a danger when it encourages rash and haphazard administration by inexperienced and unqualified persons without due selection, preparation, or examination of patients. Despite occasional reported fatalities, nitrous oxide compares very

favourably with ethyl chloride in point of safety.

Allowing for the fact that the administration of ethyl chloride has in recent years been promiscuous and indiscriminate, without regard to skill on the one hand and suitability on the other, the length of the death-roll shows this drug to be a much more dangerous agent than it was reputed to be.

By the unwritten law of custom, anæsthesia of short duration is usually induced by the dental surgeon who performs the dual rôle of anæsthetist and operator. This procedure certainly saves the patient's purse, but it minimizes his regard for the serious nature of all anæsthetics, and burdens the dental surgeon with a responsibility greater than is in my opinion justifiable. Associated with the question of the patient's safety, the surgeon's reputation is at stake, and in the case of a fatality (especially in the hands of a beginner), may be seriously jeopardized.

For operations of long duration, the services of a medical man are requisitioned. This, by virtue of the sharing of responsibility, constitutes a distinct safeguard, provided the anæsthetist is versed in dental anæsthetics, which it must be ceded is a distinct and special branch of anæsthetics. Otherwise, what should be a measure of safety, might prove an occasion of falling.

To dictate what anæsthetic agent shall be used in a given case may be a task of no little delicacy, but with his own patients, and certainly when the operation is to be performed in a dentist's own surgery, I hold that he should exercise the right of self-protection by demanding that the least dangerous anæsthetic be employed.

CHAPTER III.

THE ANÆSTHETIC.

In the search after the "Perfect Anæsthetic" an enormous number of chemical substances have been tried, only however to be discarded as a more intimate knowledge of their action has demonstrated their unsuitability for the purpose for which they were intended.

Up to the present time nitrous oxide, ether, chloroform, and ethyl chloride have alone withstood the stern test of experience, and of none of these can it be truly said that an entirely satisfactory anæsthetic agent has been found.

Anæsthetics are administered :—

1. Alone.
2. In mixture.
3. In combination.
4. In sequence.
5. Preceded by a narcotic.

These different procedures, with the exception of (5), which is not as a rule practised in dental anæsthetics, will be described in Chapters IV, V, and VI.

NITROUS OXIDE.

Nitrogen monoxide, protoxide of nitrogen, laughing gas, or "gas."

Discovered by Priestley in 1772.

First employed by Wells in 1844.

Prepared by the action of heat (460° F.) upon granulated nitrate of ammonium, and collection over water.

Chemical formula, N_2O—a gas with sp. gr. 1·5, colourless and of a sweet smell and taste. It can be liquefied at 0° C. under a pressure of 30 atmospheres, resulting in a colourless mobile fluid with sp. gr. ·937 at 0° C. Nitrous oxide is stored and supplied for use in its liquid state. Iron and steel cylinders are employed of such a size as to yield 25, 50, and 100 gallons of gas, the weight of liquid necessary to supply 25 gallons being 7·5 oz.

The sudden conversion of liquid nitrous oxide into gas is accompanied by sufficient cold to cause solidification, which is often seen as a white frost on the cylinder and fittings where the connection is faulty.

Impurities.—Other oxides of nitrogen.

Position as an Anæsthetic.—To all intents and purposes, provided that suitable precautions are taken with reference to selection and preparation of the patient, nitrous oxide is a safe anæsthetic. It is easy to give, pleasant to take, and singularly free from disagreeable after-effects. It can be administered with impunity to a patient in the sitting posture—a great convenience in dental surgery.

The fact of the Barth appliances for administering nitrous oxide and ether being made to scale, simplifies the giving of the nitrous oxide-ether sequence, and allows of its performance in those cases in which nitrous oxide only was intended and is found insufficient.

The preliminary administration of nitrous oxide obviates the unpleasantness of the early stages of ether given by the closed system.

Nitrous oxide is also employed in combination with ethyl chloride.

Disadvantages.—Nitrous oxide is only respirable to a certain degree, a continuous supply of gas with oxygen or air being required if prolonged anæsthesia is aimed at. When nitrous oxide is administered by the ordinary (oral) method, such prolongation is impossible: the patient must be completely anæsthetized and the anæsthetic withdrawn before the operation.

The rapid recovery makes anything but the shortest operation impossible. Still, this is the special rôle of nitrous oxide so administered, and the attempt to perform more than can be reasonably expected (whereby painful impressions are made in the stage of incomplete anæsthesia) results in disappointment due rather to the anæsthetist than the anæsthetic. When the nasal method is adopted, much longer operations are possible but, remembering the light nature of the anæsthesia so produced

and the occasional uncertainty of its action, it behoves us to exercise discrimination in selecting suitable cases for its employment.

Nitrous oxide, if administered pure is, for reasons to be mentioned later, unsatisfactory.

ETHER.

Sulphuric ether, ethylic ether, vinous ether, ethyl oxide, ether.

Discovered in 1540 by Cordus, who called it "sweet oil of vitriol."

First administered in 1846 by Morton.

Prepared by the dehydration of ethylic alcohol by sulphuric acid.

Chemical formula $(C_2H_5)_2O$—a liquid; transparent, colourless, and volatile, with typical odour and taste. Sp. gr. ·735 at 0° C.; boiling-point about 35° C.; vapour density 2·5 as compared with air. It is freely miscible with alcohol and chloroform, and soluble in ten times its own volume of water.

Ether vapour is highly inflammable, burning with a white luminous flame, and detonating sharply with air on the approach of a naked flame.

Varieties—

A. Prepared as above:—

i. Æther (off.), sp. gr. ·735.

ii. Æther purificatus (off.), sp.gr. ·720–·722.

B. Prepared from methylated spirit :—

i. Methylated ether, sp. gr. ·730.

ii. Rectified ether, sp. gr. ·720.

iii. Absolute ether (meth.), sp. gr. ·717–·719.

Of the above five preparations, *A* ii *and B* ii are alone adapted for the induction of anæsthesia.

For all practical purposes rectified ether is equal in value to the official product, and the cost is very much less.

Impurities.—Excess of water ; methylic ether ; aldehyde ; sulphuric, sulphurous and acetic acids ; organic and other impurities.

Position as an Anæsthetic.—Ether plays a very important part in the practice of dental anæsthetics. It is eminently safe, and by careful regulation of the induction period, the available anæsthesia requisite for a given case can be very accurately gauged.

For all long operations, i.e., those which cannot be satisfactorily performed under nitrous oxide, it is *the* agent to employ in routine practice.

It can be safely administered to patients in the sitting posture.

In our own hospital, the almost universal adoption of the open system has resulted in the diminution or abolition of most of the disagreeable concomitants and sequelæ formerly met with when the closed system was employed.

CHLOROFORM.

Discovered by Dumas in 1834.

First employed by J. Y. Simpson in 1847.

Prepared by the distillation of dilute alcohol with calcium hypochlorite, in the presence of calcium hydrate, and subsequent purification.

Chemical formula, $CHCl_3$—a liquid; colourless, volatile, and mobile, with a sweet smell and burning taste.

Sp. gr. 1·5 at 0° C.

Boiling point, 61° C; vapour density, 4·5, as compared with air.

Soluble in 285 times its own volume of water.

Miscible freely with alcohol and ether. Non-combustible, but in the presence of a naked flame is decomposed and gives off free hydrochloric acid. Causes erythema or even vesication of the skin, when in contact.

Chloroform can also be prepared from methylated spirit instead of ethylic alcohol.

Impurities.—Alcohol, butyl and amyl compounds, methylated spirit, chlorinated oils, chlorides, fixed matter.

Position as an Anæsthetic.—Chloroform, on its introduction, was considered an ideal substitute for ether, and its use spread rapidly. The death of Hannah Greener, at Winlaton, on January 28, 1848, was a rude awakening for those who had accepted Simpson's original plea of "safety," and from that day onward the

death-roll of victims has surely and steadily increased.

During the seven years 1895–1901, 65 deaths from chloroform were recorded in the *British Medical Journal*. The age incidence was as follows :—

Below 1	Between 1-10	Between 10-20	Between 20-40	Between 40-60	Over 60	Not specified	Total
2	6	16	12	13	7	9	65

The stage at which death occurred :—

Operation not commenced	Operation proceeding	Operation completed
32	15	13

Post-mortem examinations were held in 32 cases, with the following results :—

Heart found normal	Heart diseased
15	17

Furthermore, 12 of the cases had previously undergone chloroformization, a serious argument against the " status lymphaticus " theory.

The deaths were variously attributed to syncope, asphyxia, shock, and fits. The operations varied from tooth extraction to major amputations and abdominal surgery. In one

case the upright position was adopted. These data pretty well illustrate our knowledge of chloroform as follows :—

1. Chloroform is dangerous at all ages.

2. Death is particularly apt to occur during the induction stage.

3. Previous safe chloroformization is no guarantee of safety.

4. Chloroform can kill the obviously healthy.

5. The gravity of the operation is not *per se* an indication of the danger.

6. The cause of death is a matter for theorization only.

As to the actual cause of death, two schools of thought exist.

Syme and Lister taught that chloroform killed by causing primary respiratory failure.

Snow, Anstie, Clover, and Richardson, on the other hand, held that death resulted from circulatory failure due to over-dosage.

In July, 1901, the Council of the British Medical Association appointed a special committee to investigate methods of quantitatively determining the presence of chloroform in the air and in the living body.

The ultimate object of the Committee was to determine, if possible, the minimal dose of the drug necessary to secure an adequate anæsthesia for operation, without at the same time endangering life. The practical outcome of the

investigations so instituted is an inhaler, invented by Vernon Harcourt, capable of supplying accurate percentages of chloroform in the inspired air. By its use we now know that only 1 to 2 per cent of chloroform is necessary to produce surgical anæsthesia, and ·2 per cent only is required to maintain anæsthesia so produced. Moreover, the fatal dose does not exceed double that required to induce anæsthesia. Although the question of the safety of chloroform is still *sub judice*, we have at any rate learned that the old system and methods of administration were and are chiefly to blame for the mortality. If 2 per cent is the maximum amount necessary to induce anæsthesia, and 4 per cent is in the danger area, what can be said in favour of the procedure of giving chloroform on lint, whereby a percentage is inhaled variously estimated at 4·5 (Lister), 9·5 (Snow), and 13 (Samson) ?

Chloroform in Dental Surgery.—If I have spoken strongly with reference to the danger of chloroform, it is because I feel strongly that the use of chloroform in dental surgery must be interdicted, and it rests with the dental profession to bring this about. As I have already stated, neither the operations which will have to be performed, nor the conditions for which such operations are indicated, entail *per se* any risk to life. To endanger the life

of a patient in such circumstances, therefore, is unjustifiable, and would not be tolerated for one moment if public opinion became enlightened on the subject.

The requirement of a dental anæsthetic is *safety*; hence the administration of chloroform should not even be considered, save by the method initiated by Harcourt. Even then, it cannot be urged with truth that this method is safer than ether, and the disadvantages of the horizontal position are obvious.

Were chloroform the only anæsthetic agent at our command, then, on their own responsibility, patients incapable of bearing pain might be allowed to take the risk. But with open ether and the nitrous oxide-ether sequence as alternatives, the deepest censure is due to that individual who is associated with a death under chloroform administered for a dental operation.

ETHYL CHLORIDE.

Prepared in a flask with an inverted condenser, by the passage of hydrochloric acid into a boiling solution of chloride of zinc in ethylic alcohol.

Chemical formula, C_2H_5Cl. A liquid; colourless, very volatile, with pungent odour. Sp. gr. ·921 at 0° C. Boiling point, 12·5° C.; vapour density, 2·2. The low boiling-point necessitates storage in sealed vessels.

Position as an Anæsthetic.—Although the anæsthetic properties of ethyl chloride were pointed out by Flourens the year following the introduction of ether, and Heyfelder employed it with success a year later, it was allowed to fall into disuse, and was not revived till 1895.

Since then ethyl chloride has enjoyed all the advantages and drawbacks associated with a "boom." As to its potency as an anæsthetic agent, there is no manner of doubt, and so long as the dictum of its safety was not brought into question it seemed as if the ideal anæsthetic for dental surgery had been found. The same fate, however, that befell chloroform has been meted out to ethyl chloride. An ominously long death-roll has called us to exercise caution and to reconsider our position.

Hewitt describes it as "far more dangerous than nitrous oxide, and distinctly more dangerous than ether." Before recommending its use in dental surgery, we must, I think, ask ourselves the question, "Are we justified, for the sake of a few seconds longer available anæsthesia than is obtained with nitrous oxide, or a shorter induction period than that existing with ether, in allowing our patients to risk their lives?"

CHAPTER IV.

THE ADMINISTRATION.

In hospital practice in this town, operations are performed early in the forenoon—which is the most suitable time for appointments to be made.

It is not advisable to administer an anæsthetic to a patient who has recently had a solid meal, owing to the greater liability to, and the risks attending, vomiting—three to four hours should elapse.

A basin of beef-tea or fluid meat-extract may be given two hours previous to the operation, and in the case of a debilitated patient an ounce of brandy may with advantage be added.

Milk should be avoided—clots, when vomited, may cause obstruction.

Immediately before commencing the administration, the following points should be attended to :—

1. If not already ascertained, the health of the patient should be investigated, especially as to the presence of :—

a. Epilepsy.

b. Heart disease—the condition of the

muscular walls is of more importance than the actual state of the valves.

c. Arterio-sclerosis and atheroma.

d. Lung affections.

2. The bladder should be emptied, especially in the case of women and children.

3. All tight clothing should be loosened, particularly neck bands, waist bands, and corsets.

4. A comfortable posture must be sought, avoiding too great depression of the chin, or over-extension of the head.

5. The correct posture for the special anæsthetic to be employed must be borne in mind.

6. The mouth should be examined for dentures or loose teeth.

7. The upper respiratory tract should be cleared of mucus and the mouth rinsed with an antiseptic (such as carbolic acid 1 in 40 of water).

8. A prop, if required, should be inserted.

9. The following requisites should be at hand :

a. Sponges—stringed and on holders—or swabs of cotton-wool.

b. Mouth opener or gag. The gag should be all-metal, with ratchet spring, handles 3 inches long, and blades capable of separating to 2–2½ inches.

c. Tongue forceps.

d. Tracheotomy and laryngotomy tubes,

and the necessary instruments for the performance of these operations.

e. Capsules of amyl nitrite.

f. Hypodermic syringe, solution of strychnine.

g. Ether, spirit. ammon. aromat., brandy.

Observe also that :—

10. The name and address of a new patient coming alone should always be noted.

11. A female patient should never be anæsthetized save in the presence of a reliable witness.

Definitions.

System.—The broad principle regulating the administration of an anæsthetic.

Method.—The particular technique adopted in inducing anæsthesia under a given system.

NITROUS OXIDE.

Systems of Administration :—

(*A*). Nitrous oxide pure.

(*B*). Nitrous oxide with air : (*a*) oral method, (*b*) nasal method.

(*C*). Nitrous oxide and oxygen.

Apparatus for Administration :—

1. *The Gasometer*—to which proceeds a supply pipe admitting nitrous oxide from a cylinder, and from which proceeds a delivery tube con-

veying nitrous oxide through a two-way stop-cock to a face-piece provided with an expiratory valve.

2. *Bag and stop-cock* (Barth).—A three-gallon rubber or silk bag is connected up at the distal end, by means of tubing, to a supply cylinder. The proximal end of the bag can be attached to a rectangular 3-way stop-cock bearing a closed face-piece. The stop-cock is so arranged that, by means of valves, regular inspiration may be :

i. Direct from the air.
ii. Direct from the bag.

and expiration may be :—

i. Into the air.
ii. Into the bag.

3. *Apparatus for nasal inhalation.*—Much ingenuity has been exercised in designing, modifying and improving an apparatus for administering nitrous oxide by the nose, and so maintaining anæsthesia during the performance of dental operations. With this work the names of Coleman, Paterson, Hilliard, Trewby, and Kirkpatrick are indissolubly associated. Space will not permit me to discuss the advantages claimed for the different types of apparatus : with a thorough knowledge of the necessary technique it is no doubt possible to obtain satisfactory results with any one of them. It will suffice here to describe briefly Trewby's nasal inhaler.

A rubber bag, of 1½ gallon's capacity, is connected up at its proximal end with a bifurcating metal joint (containing an inspiratory valve) to which are attached two wide-bore rubber tubes 18 inches long. These tubes at their other extremity are connected to the nasal cap.

The nasal cap is made of metal, and the orifice on its posterior surface is designed to fit accurately over the nose. The anterior surface is convex, and has at its upper part a rectangular aperture into which is grooved a sliding metal diaphragm bearing on its convex surface a rotary angular mount. When the mount is directed forwards, nitrous oxide or air can pass through it from the nasal cap, but the passage is occluded by rotation to the left. At the summit of the mount is placed an expiratory valve.

At the lower end of the inner surface of the nasal cap is a well into which opens, on either side, a tube which gives attachment to its corresponding rubber tube proceeding from the joint.

When the sliding diaphragm is adjusted so as to open the air aperture, the well is covered and the supply of nitrous oxide cut off; when the air aperture is closed, the supply of nitrous oxide is unimpeded. By regulating the size of the air aperture varying proportions of nitrous oxide and air can be administered.

The oral cap, also made of metal, is capable of accurate adjustment to the margins of the lips when the mouth is propped open. The outer surface has an opening below, which communicates, by means of a wide-bore rubber tube eight inches long, with the angular mount of the nasal cap. With the oral cap *in situ*, the mount is patent for the passage of nitrous oxide or air. Above this orifice is fixed an expiratory valve. To maintain uniform gentle pressure, and allow of its increase if required, a metal compressor is attached to the bag. A useful contrivance permits of the bag being brought forward into view of the anæsthetist.

4. *Apparatus for the simultaneous administration of nitrous oxide and oxygen* (Hewitt).—This consists of (*a*) a double bag, each half of which is connected at its distal end with a cylinder of nitrous oxide and a cylinder of oxygen respectively, and at its proximal end with (*b*) a rectangular, double-channelled, two-way stop-cock fitted with one expiratory and three inspiratory valves and an air aperture. In the bend of the stop-cock is a mixing chamber into which nitrous oxide can enter direct; the entrance of oxygen, however, is barred, and can only take place through ten little perforations which can be opened and shut at will by manipulating an indicating lever. From the mixing chamber the gases pass direct to (*c*) a closed face-piece.

Asphyxia.

Nitrous oxide produces its effects by virtue of its properties as a general anæsthetic. Obviously, therefore, the frequent incidence of asphyxial symptoms is adventitious. The sequence of phenomena in asphyxia is :—

i. Hyperpnœa, dyspnœa, and cyanosis.
ii. Tonic and clonic muscular contractions.
iii. Exhaustion and unconsciousness, terminating in death.

The first two stages resemble closely those seen when nitrous oxide is administered pure—they are due in both cases to oxygen deprivation ; hence it follows that, since the administration must be discontinued if the fatal third stage is to be avoided, operations are often performed before anæsthesia is completed.

Asphyxia is *not* anæsthesia, and its occurrence is preventable.

A.—NITROUS OXIDE PURE.

Average length of induction period, 60 seconds.
Average available anæsthesia, 30 seconds.

Method of Administration :—

1. The patient is seated upright in the chair, and the head-rest accurately adjusted.

2. Residual gas or air should be expressed from the bag, and a stream of fresh gas allowed to flow through.

3. The bag should be three-quarters full and the gas maintained at this pressure throughout.

4. A mouth-prop should be inserted. A useful form is the ordinary metal prop with replaceable rubber caps. For safety, as well as for convenience, it is usual to string two or three of different sizes together. If fissures exist at the angle of the mouth, they should be smeared well with vaseline.

5. The face-piece should be accurately adjusted, noting that all air is excluded—in the case of men with beards the application of soap or oil will assist.

6. The patient should be encouraged to breathe slowly and quietly.

7. The respiratory cycle being established, gas is admitted by manipulating the stop-cock.

8. When snoring commences, or asphyxial symptoms (jactitation, cyanosis) appear, the face-piece should be removed and the operation allowed to proceed.

For reasons already given, nitrous oxide so administered is liable to prove unsatisfactory to both patient and operator, and it is better to substitute one or other of the following procedures.

B.—NITROUS OXIDE WITH AIR.

(*a*). Oral Method.

Average induction period, 90 seconds.

Average available anæsthesia, 45 seconds.

The available anæsthesia varies considerably in different cases. I have obtained as long as 90 seconds—often over 60 seconds. Generally speaking, it works out at half the length of the period of induction.

Method of Administration:—

1 to 7, as in "Nitrous Oxide Pure."

8. *The admission of air.*—This may be continuous or intermittent. In the former case the stop-cock is adjusted so as to allow a thin stream of air to enter and be inspired with the nitrous oxide.

By modifying the size of the aperture to meet the special requirements of the case, quiet anæsthesia, without cyanosis or jactitation, can be obtained.

In the intermittent method, pure nitrous oxide should be given till the first evidence of hyperpnœa. The air inlet should then be kept open during a complete respiration. By adopting this procedure every five or six respirations, anæsthesia similar in character to that described above can be obtained.

9. The indication to operate is the occurrence of a typical deep stertor. The corneal reflex is not necessarily completely abolished. The pupil is dilated.

10. Should signs of returning consciousness

appear before the completion of the operation, the face-piece should be immediately re-applied.

11. On no account may a second administration be made after complete recovery.

To-and-fro Breathing.—This is permissible only towards the end of the induction.

Advantages.—(1) Prolongation of induction period and consequently of the available anæsthesia ; (2) completion of anæsthesia when the supply of nitrous oxide runs short.

Disadvantages.—(1) Fouling of the bag ; (2) increased tendency to after-headache and nausea.

(*b*). **Nasal Method.**

The *raison d'être* of nasal inhalation is continuous administration ; it is in reality a combined form of continuous and intermittent supply of air with nitrous oxide. At first air in varying quantities enters by the mouth, but as consciousness is lost the breathing tends to become entirely nasal in character, necessitating the mechanical admission of air to the inspiratory current.

The nasal method of administering nitrous oxide is making rapid strides in favour : that it may eventually replace the oral method is likely, but that it will oust ether is to my mind unthinkable. Let me urge at the outset that the anæsthetist who wishes to become expert in this method must obtain his efficiency by

continual practice. To employ the oral method as his routine procedure, and only adopt the nasal method for difficult and extended operations, is to court frequent failure. There is no reason why the nasal method should not be used for the most simple operation, but there are two types for which it is particularly suitable.

The first comprises those cases where oral administration just fails to produce a sufficient available anæsthesia, so that the operation is hurriedly completed during the period of recovery, or else discontinued till anæsthesia can be again induced at the same or a subsequent sitting.

The second type includes those cases of simple multiple extractions which obviously cannot be performed during the available anæsthesia of the oral method, yet it is imperative that the operation be completed outright at one sitting. It is for such cases that the services of an anæsthetist are most frequently requisitioned, and hitherto ether has been used as a matter of routine.

There is, however, a class of case where one instinctively knows that the operation must be prolonged and severe. For such it is better to administer ether and so ensure a deeper phase of anæsthesia, with a certainty of completion.

To maintain surgical anæsthesia for a long

period by the nasal method of administering nitrous oxide is never a foregone conclusion. The onset of asphyxia, as evidenced by increasing cyanosis, demands the immediate admission of air, which admission is extremely apt to be followed by temporary apnœa, during which recovery gradually occurs. To re-induce anæsthesia in such cases is difficult and not altogether free from danger. The distance between asphyxia on the one side and incomplete anæsthesia on the other is surprisingly short, and the *via media* of satisfactory anæsthesia is a path by no means easy to traverse. Lastly, bearing in mind the difficulties we at times encounter in inducing even a brief anæsthesia by the oral method of administering nitrous oxide, we must not be surprised if we find the nasal method subject to like difficulties.

Method of Administration :—

1. It must be assured that the nasal passages are free. The nose should be cleared by blowing each nostril separately.

2. Wherever possible, the mode of procedure should be explained to the patient and his co-operation enlisted.

3. The precautions detailed on pages 27–29 should be observed, special care being taken to ensure an adequate supply of nitrous oxide,

since "to-and-fro" breathing cannot be employed.

4. The patient should be placed in the semi-recumbent position: thus a more satisfactory view is obtained of the patient and of the progress of the operation.

5. A prop having been inserted, the nasal cap is applied with the air aperture open, and the patient is directed to inspire quietly through the nose, and expire preferably through the mouth, though this is not absolutely essential. As soon as regular breathing is established, gas is admitted and the supply of air cut off. Usually, as consciousness is disappearing, the breathing becomes entirely nasal in character.

If the onset of anæsthesia be retarded, the oral cap must be applied, and the induction continued as by the oral method. Evidences of commencing asphyxia are to be met by manipulating the air aperture.

6. If nasal breathing be satisfactorily established, the operation may be commenced at an earlier stage than with the oral method.

7. Should recovery occur, either from excessive mouth breathing or as the result of apnœa, before the operation is completed, the re-application of the oral cap is a safer procedure than is "forcing" the anæsthetic under pressure. This latter expedient, by impeding expiration, may lead to dangerous symptoms.

8. There is a type of patient in whom, owing to shortness of the soft palate and failure to approximate it to the tongue, free expiration by the mouth is unavoidable. Anæsthesia is consequently difficult to maintain unless recourse is made to the Trewby-Dinnis oral shield. This contrivance (which is provided with an expiratory valve), if applied so as to occlude the anterior pharynx, cuts off the excessive air supply, and serves the further purpose of barring the passage of foreign bodies to the larynx.

9. On the conclusion of the operation the patient should be lowered to the horizontal position, and the mouth emptied of blood by turning the head to one side.

10. The period of induction is not as a rule longer than is met with when the oral method is used, and the signs of surgical anæsthesia are less complicated by evidences of asphyxia. The available anæsthesia is practically unlimited, but it is questionable whether very prolonged nitrous oxide anæsthesia is as safe as that resulting from ether.

11. Allowing for the increased duration of anæsthesia and the greater shock of the operation, it is not found that the after-effects are materially greater than those met with after oral administration.

12. The use of the nasal method necessitates the presence of an independent anæsthetist.

C.—NITROUS OXIDE AND OXYGEN.

Average period of induction, 2 minutes.
Average available anæsthesia, 45–90 seconds.

Method of Administration:—

The usual precautions already detailed having been observed, the bags should be half filled and maintained at the same pressure throughout the administration by regulating the supply of nitrous oxide. It is usual to commence with the indicator at 2, and gradually to increase the proportion of oxygen till a maximum of 8 is reached.

The necessity for more oxygen is shown by the advent of asphyxial symptoms. Less oxygen is indicated if excitement (muscular or vocal) appears.

The anæsthesia so produced is quiet and free from asphyxial manifestations, and is the ideal we aim at in administering nitrous oxide and air.

The technique is probably the most difficult to master and carry through successfully, and the apparatus is cumbersome, costly, formidable to the patient, and very prone to get out of order. The after-effects of the anæsthesia, moreover, are more serious. The results obtainable with nitrous oxide and air are so satisfactory, that it becomes a moot point whether the outlay on apparatus and the time spent in

gaining the necessary proficiency are justified by results. Some such contrivance as that designed by Trewby for the employment of oxygen with nitrous oxide administered by the nasal method promises a greater sphere of usefulness. The oxygen in this case need not be used as a matter of routine, but only if the occasion requires it.

Dangers of Nitrous Oxide Anæsthesia.

Circulatory :—

1. *Syncope before administration.*—Due to fear, or exhaustion from pain, hunger, or sleeplessness. It need hardly be insisted that no attempt should be made to administer the anæsthetic till all evidence of heart failure has passed off.

2. *Syncope during the administration.*—

   i. From reflex action due to the infliction of pain during incomplete anæsthesia ; this is a rare occurrence, but its possibility in a case of heart disease must be borne in mind.

   ii. Circulatory failure secondary to, or simultaneous with, respiratory failure.

3. *Syncope following administration*—is always a possible concomitant of a second induction following complete recovery, and should prove a powerful deterrent to this procedure.

Respiratory :—

1. *Peripheral.*—
   i. From without. Asphyxia due to :—
      a. Tonic spasm fixing the muscles of the respiratory mechanism ;
      b. Obstruction from faulty posture ;
      c. Compression of the neck and waist by tight clothing ;
      d. Tumours compressing the trachea—goitre, aneurysm.
   ii. From within.
      a. Growths of naso-pharynx ;
      b. Foreign bodies—vomited matter, artificial dentures, teeth, broken forceps, sponges and swabs, mucus, blood.

2. *Central.*—Asphyxia due to overdose or prolonged deprivation of oxygen, primary to, or combined with, circulatory failure.

After-Effects.

Headache is a frequent occurrence, particularly in that type of patient subject to the condition. It is most common when asphyxial symptoms have occurred, and after to-and-fro breathing.

Vomiting may be cerebral or gastric in origin. If the former, it is associated with headache, and attacks those patients already mentioned. If the latter, it is usually due to lack of preparation, and is preventable. Vomit-

ing is very prone to occur during a second administration.

Hysterical manifestations, catalepsy, prolonged stupor, and insanity have been recorded.

Cerebral and retinal hæmorrhages may occur during the administration, and manifest their presence after recovery.

Contra-indications.

Circulation :—

1. *The Heart.*—The condition of the muscular walls is of greater import than the competency of the valves. A feeble, irregular, or intermittent pulse would call for caution. Mitral stenosis and aortic regurgitation are the most dangerous valvular lesions.

2. *The Blood-Vessels.* — Atheroma and increased arterial tension, by virtue of the tendency to internal hæmorrhage, are contra-indications to safe anæsthesia.

Respiration :—

Tumours compressing the larynx or trachea ; phthisis with hæmorrhage.

Menstruation.

The anæsthetizing of a female except in the presence of a reliable witness, has already been warned against. This caution is necessary owing to the frequent charges of rape and criminal assault preferred by patients. Such

charges, made in all good faith, depend upon a heightened sexual irritability, which is more likely to occur during the menstrual epoch.

Should the necessity for the operation be urgent, shock is less liable to result if anæsthesia be employed.

Pregnancy.

It is inadvisable to administer an anæsthetic during pregnancy.

Should the necessity arise, however, a preliminary consultation with the family medical attendant must always be sought.

CHAPTER V.

THE ADMINISTRATION (*continued*).

ETHER.

Systems of Administration:—

(*A*). *The Open System*; (*B*). *The Semi-open System*; (*C*). *The Closed System.*—(1) Ether only; (2) Ether preceded by nitrous oxide; (3) Ether preceded by chloroform.

A.—THE OPEN SYSTEM.

Till quite recently it was recognized as almost axiomatic, that the open system of administering ether was useless except in the case of young children and debilitated adults. We now know that such an impression is quite erroneous, and that this very system, so long discredited, is in fact "the ideal."

True, in certain cases, e.g., powerful muscular men and alcoholic subjects, a certain difficulty in inducing anæsthesia may be encountered, but even in the majority of these cases, a more enlightened knowledge of the means at our disposal enables us to minimise, if not entirely dispose of, difficulties.

The advantages of the open system are :—

1. *The Elimination of the Asphyxial Element.*—Most of the disadvantages urged against ether are attributable to the asphyxia produced in the administration by the closed system. I allude to the free venous hæmorrhage, increased secretion of mucus, loud stertorous breathing with tumultuous respiratory movements, and the after malaise, headache, nausea, and vomiting. These are almost entirely avoided by adopting the open system, which procedure results in a quiet, peaceful anæsthesia, resembling that produced by chloroform, but devoid of the dangers and the inconvenience of the horizontal position associated with the latter anæsthetic.

2. *The Simplicity of the Apparatus and its consequent Cleanliness.*—The apparatus made for me by Brady & Martin, Ltd., Newcastle-upon-Tyne, consists of (*a*) a wire framework, over which is placed a pad consisting of eight layers of gauze between two layers of lint. This is retained in position by (*b*) a wire rim with lateral clamps. The mask so formed is separated from actual contact with the face by a roll of gauze crossed above to form eye-pads.

3. *Absence of After-effects.*—Recovery is extremely rapid, and, as stated above, is attended by very slight after-effects.

4. *Rapid Completion of the Operation.*—It is easy in the greatest number of cases to gauge the exact depth and duration of anæsthesia required, hence a second application is rarely needed.

Method of Administration :—

The necessary ritual as regards preparation having been carried out, the patient is seated in the chair. The roll of lint is placed on the face with the centre below the lower lip, and the ends are brought up outside the mouth and nose, and crossed at the bridge of the nose, to cover the closed eyelid on the opposite side. The mask is held so that the margin rests lightly on the bed so formed.

The ether is applied *very slowly* from an ordinary 8-oz. dispensing bottle, fitted with a rubber cork and 2-channelled drop-tube.

In the early stages I encourage the patient to talk, and anæsthesia is induced gradually and imperceptibly. In the case of very nervous subjects, counting is often useful.

Should there be a tendency to cough or hold the breath, a few inspirations through the nose may be recommended. As consciousness gradually becomes lost, the ether is applied more copiously, but " drenching " must always be avoided.

Struggling is rare. Just before complete

anæsthesia ensues, coughing of central origin often occurs, and through alteration of the position of the head and neck may result in dyspnœa.

By tilting the head forward, and "pushing" the anæsthetic, the cough is readily controlled.

The average period of induction is ten minutes, and the average amount of ether used is 2 oz., varying of course above and below these figures with the physique, age, state of health, and nervous temperament of the patient, and the available anæsthesia required. Ether so administered is extremely pleasant to take.

In those rare cases where the production of surgical anæsthesia is difficult or delayed, a folded towel placed over the mask will sufficiently concentrate the vapour temporarily, to allow of the desired result being obtained.

Signs of Surgical Anæsthesia :—

1. Complete muscular relaxation.
2. Regular audible respiration.
3. Absence of corneal reflex.
4. A slightly dilated pupil—larger than that met with in chloroform anæsthesia, but smaller than that which occurs with closed ether.

B.—THE SEMI-OPEN SYSTEM.

As its name implies, this occupies a position midway between the open and closed systems. The apparatus consists of a cone-shaped mask

constructed of metal, celluloid, or leather, perforated at the closed end. It is lined with domette or flannel, and has a sponge at the perforated end. Ether is poured on to the sponge and the mask applied to the face. The method is crude, intensely unpleasant for the patient, and difficult to regulate owing to the absence of any attempt at graduated dosage.

I cannot imagine any cases in which the semi-open system would be more advantageous than the open system just described.

Over the closed system it possesses the advantages of simplicity and cleanliness, which, however, are more than balanced by its crudity and unreliability.

C.—THE CLOSED SYSTEM.

1. Ether only:—

Apparatus.—Clover's inhaler: Barth's pattern. This consists of three portions—a central chamber, a closed face-piece, and a rubber or silk bag of one gallon capacity. The central chamber comprises two parts: (*a*) an outer dome-shaped metal cylinder (capable of holding two ounces of ether in its lower portion), penetrated by a central canal which communicates on one side with the interior of the cylinder by means of two horizontal slits—one above and the other below the

middle line. On the opposite side of the canal is a shallow well, reaching above and below the middle level. Fitting into the canal is (*b*) a hollow metal tube, divided into two parts by a mesial diaphragm, and extending above to give attachment to a rectangular connection with the bag, and below with the face-piece. On one side are two horizontal slits, one above and the other below the diaphragm. Between the cylinder and the face-piece is fixed an indicator.

On the lower rim of the cylinder are engraved 0, 1, 2, 3, and F. By rotation of the cylinder the indicator points towards any one or other of these numbers.

The principle of the apparatus is as follows:—when the indicator on the tube points to the number 0 on the cylinder, the slits in the tube are immediately contiguous to the well on the inner surface of the cylinder, so that the respired air passes directly to and from the bag.

When the indicator points to F., the slits in the tube are superimposed upon the slits in the cylinder, so that all the respired air passes over the ether vapour. With the indicator at 2, half of the air traverses the chamber, and half passes direct to and from the bag; at 1, one-quarter of the air traverses the chamber, and three-quarters pass direct to and from the

bag; at 3, three-quarters of the air traverses the chamber, and one-quarter passes direct to and from the bag.

The Administration. — In administering ether alone, two methods are recognized:—

i. *For children, women, and delicate men.*—The ether vapour should be added very gradually, and the bag should not be affixed for to-and-fro breathing until the indicator points to 2.

ii. *For muscular men.*—The induction should be more rapid, and the concentrated ether vapour added to the respiratory current quickly by the early assumption of to-and-fro breathing.

Points of importance:—

i. During the stage of induction the admission of fresh air causes extreme chilling of the upper respiratory tract, with resulting coughing and other evidences of respiratory difficulty. Except in extreme asphyxia or spasm causing arrest of respiration, the anæsthetic should be "pushed" till anæsthesia is complete.

ii. Late retching and coughing of central origin are frequent just before surgical anæsthesia occurs, and indicate a further supply of the anæsthetic rather than its withdrawal.

iii. If the necessities of the operation indicate a long available anæsthesia, the patient should be "charged up" before the operation is allowed to commence. This is done by withdrawing the inhaler and waiting for all sym-

ptoms of asphyxia to disappear ; the inhaler is then re-applied and a deeper phase of anæsthesia is reached.

This procedure may be repeated as often as is thought necessary. By so doing, rapid recovery is prevented, and the troublesome re-anæsthetization of the patient during the partially completed operation can be obviated.

iv. The signs of complete anæsthesia are :—

a. Loud, regular, stertorous breathing, more pronounced in the case of robust full-blooded patients, and depending to a great extent upon the concomitant asphyxia introduced by this system of anæsthetizing.

b. Absence of corneal reflex.

c. A moderately dilated pupil.

v. The phases of anæsthesia detailed above cannot be identified in the short time required for a dental operation.

2. The Nitrous Oxide - Ether Sequence.

This variation of the closed ether system was introduced to obviate :—

i. The unpleasant taste and smell, and the irritation of the upper respiratory tract experienced at the commencement of induction.

ii. The troublesome muscular movements of the intermediate phase.

It may be employed :—

i. *To prolong nitrous oxide anæsthesia,* in which case the gag is inserted and nitrous oxide administered, as already described. As surgical anæsthesia is approaching, the ether is turned on just sufficiently to obtain the required available anæsthesia.

ii. *For the complete operation.*

Apparatus.—Barth's gas and ether inhaler.

The Administration.—No gag is inserted, otherwise nitrous oxide is given in the usual way. After the first few breaths, however, the ether apparatus is gradually brought into play. Just prior to completed nitrous oxide anæsthesia the gas bag is removed and the ether bag substituted.

Ether anæsthesia is induced as described above.

" Charging up " is to be employed if necessary.

3. The Chloroform-Ether Sequence.

This is, from the patient's point of view, an extremely pleasant method of taking ether. Chloroform is given on lint, and ether (either open or closed) applied when consciousness is partially lost. It, however, lacks the element of safety so marked in the case of open ether or the nitrous oxide-ether sequence, and moreover necessitates the adoption of the horizontal position.

Contra-indications.

The objections urged against ether are :—

1. The unpleasant smell and taste of the drug, and its irritating effect upon the upper respiratory tract as evidenced by cough and spasm during the initial phases.

As regards the former, I believe that ether inhaled by the open system is quite pleasant—a few drops of eau de Cologne or lavender water applied to the pad will entirely overcome any objection on this score. As regards the latter, the slow, gradual exhibition of the drug in open ether, or the preliminary administration of nitrous oxide with closed ether, will suffice to prevent its occurrence.

2. The increased secretion of mucus and greater tendency to hæmorrhage.

These phenomena only obtain with closed ether, and depend upon the degree of asphyxia present. They can be avoided, or at any rate markedly decreased, by the "charging up" process already described.

3. Respiratory embarrassment in chronic bronchitis, emphysema, and asthma.

In these conditions ether is difficult to administer and may increase the existent trouble. The preliminary exhibition of nitrous oxide, the very gradual administration of ether, or a judicious addition of chloroform will usually solve the difficulty.

The undoubted evil effects of prolonged etherization in these diseases, and the question of the occurrence of ether pneumonia, have not to be faced in connection with dental surgery.

4. In cases of high arterial tension and brittle arteries, ether, by virtue of its tendency to raise blood-pressure, certainly constitutes a danger. In such conditions, however, any general anæsthetic is to be avoided for dental operations.

Dangers.

Dangers from etherization for dental operations are practically non-existent in the case of a moderately healthy patient, provided that proper precautions before and during the operation are regarded.

The special risks associated with ether anæsthesia are :—

1. *Respiration.*—Embarrassment or cessation due to :—

i. Spasm of masseters, tongue, and larynx.
ii. General spasm of the muscles of the neck, chest, or abdomen.
iii. Reflex shock from operation during incomplete anæsthesia.
iv. Overdose.

These are either preventable, or, as a rule, amenable to treatment. General spasm is the most dangerous, but happily its occurrence is extremely rare.

2. *Circulation.*—Syncope in healthy patients is practically unknown, but may occur :—

i. Secondary to respiratory embarrassment in cases of dilated or fatty hearts.

ii. As the result of surgical shock.

iii. From over-dose, in which case it results secondarily to respiratory failure.

After-Effects.

1. Unpleasant taste and characteristic odour of breath of somewhat lengthy duration.

2. Vomiting—almost constant after closed ether; often violent in character, but less persistent than after chloroform. Often absent and rarely severe after open ether.

3. Headache is frequent, but its presence is in direct proportion to the amount of asphyxia attending the induction.

4. Respiratory complications.

Lobular pneumonia, acute pulmonary œdema and infarct have been described as resulting from prolonged etherization, usually for abdominal operations. So many other causative factors are at work—sepsis, exposure, interference with respiration by incision of the abdominal parietes and tight bandaging—that the ether administered is probably not alone to blame—witness the occurrence of pneumonia after spinal analgesia.

CHAPTER VI.

THE ADMINISTRATION (*continued*).

CHLOROFORM.

[N.B.—After the emphatic manner in which the use of chloroform has been condemned, a description of its administration seems almost a contradiction of principle. Since, however, this book may fall into the hands of those whose sphere of work lies in other lands, where, either from exigencies of climate or difficulty of transport, chloroform is the only anæsthetic available, this brief account of the subject is included for their guidance only.]

The open system in one form or another is always employed.

Methods:—

1. Simpson's original method. A simple handkerchief in cup-like form (into the hollow of which about 1 drachm of chloroform is poured), is applied to the face, and the vapour is exhibited powerfully and speedily.

2. A folded cloth or towel (well supplied with chloroform) held close to the mouth and nostrils.

3. A single layer of lint, the chloroform being administered slowly guttatim.

4. A metal frame, such as Skinner's (covered by a layer of domette) or Schimmelbusch's (in which is fixed a layer of lint, and which possesses a gutter-like rim to prevent dripping of the chloroform on to the face).

5. Junker's inhaler, whereby chloroform vapour is pumped from a bottle to a face-piece resembling a Skinner's mask, and inhaled with the inspiratory air.

6. Vernon Harcourt's regulating inhaler, capable of allowing the inhalation of definite percentages of chloroform.

By whatever method employed, chloroform must be administered in the horizontal position.

The advent of surgical anæsthesia is indicated by :—

1. Regular stertorous breathing, deeper and more rapid than normal.

2. A slightly dilated pupil.

3. Absence of corneal reflex.

Dangers.

I have already (page 24) expressed my views as to the position of chloroform as a dental anæsthetic. It would be out of place here to devote time to an analysis of the cause of death from chloroform. Probably many factors are at work—individual susceptibility, varying in the same individual at different times ; the status lymphaticus ; mental states ; posture ;

reflex action from surgical procedures ; vomiting, actual or threatened ; and over-dose. Of these the last named is of the most importance. Whether respiration or circulation is the first to succumb, is still a matter for conjecture. Certainly in many cases of respiratory failure the heart can still be felt beating, and a return to safety can often be brought about by the performance of artificial respiration.

When, however, respiratory failure occurs secondarily to circulatory failure, the situation is fraught with dire peril, and the probability of restoring the patient depends upon the extent to which this depression has progressed.

After-Effects.

Generally speaking these are slight.

Vomiting is less frequent than after closed ether, but when present is apt to be persistent and severe.

Abnormal mental states of long duration may occur in hysterical and neurotic subjects.

Cerebral hæmorrhage has been recorded.

Acid intoxication and fatty degeneration of viscera are occasional sequelæ of prolonged anæsthesia.

Mixtures Containing Chloroform.

Realizing the dangerous properties of chloroform, it is not surprising that attempts have

been made to reduce its toxicity by the admixture of other agents. The best known mixtures are :—

a. Alcohol, chloroform, and ether, in the proportion of 1, 2, 3 parts of each—known as the A.C.E. mixture.

b. Chloroform and ether, in the proportion of 2 parts to 3 (Hewitt).

c. Chloroform and ether, in the proportion of 1 part to 3—known as the Vienna Mixture.

When we refer to the different vapour density and boiling point of chloroform and ether, it is difficult to conceive that the ether added does more than dilute the chloroform. A very much smaller dose of chloroform than of ether is necessary to produce anæsthesia, so that the actual amount of ether inhaled can hardly produce much effect upon the circulation or respiration.

As for the alcohol in the A.C.E. mixture, its effect other than that of a diluent is absolutely nil.

Methylene, or bichloride of methylene, is probably a mixture of chloroform and methylic alcohol.

ETHYL CHLORIDE.

Average time of induction, 50 seconds.

Average duration of available anæsthesia, 70 seconds.

Average amount of anæsthetic required, 2–3 c.c. for children and weakly women ; 5–10 c.c. for healthy adults.

Systems of Administration :—

The Open and Semi-open Systems have been tried, and are, in the present state of our knowledge, except in the case of young children (in whom, in fact, anæsthesia is often induced accidentally when spraying the gums prior to extraction) considered unreliable. Some form of apparatus, therefore, is employed to induce anæsthesia by the *Closed System*. In choosing an apparatus, two points of importance must be borne in mind :—

1. The connecting tubes should be of wide bore.

2. The anæsthetic should be capable of being admitted gradually.

Many different forms of apparatus are on the market, and of necessity new appliances are continually making their appearance.

A simple and useful apparatus consists of a modification of Barth's ether inhaler connection.

The ethyl chloride can either be sprayed into the bag through an opening in the rectangular connection (which is attached direct to the face-piece), or tilted into the bag by means of a graduated glass tube inserted into the distal

end. Other useful appliances are Hewitt's apparatus; Kingsford's wide-bore inhaler; Vernon Knowles' inhaler.

Ethyl chloride may also be employed :—

1. In combination with nitrous oxide.
2. In sequence—
   i. With ether, to replace nitrous oxide ;
   ii. With chloroform.

In considering the anæsthesia produced by ethyl chloride, we have to observe that :—

1. The effects of the inhalation are extremely rapid, no classification of phases being possible.

2. The anæsthesia tends to become even more profound after the apparatus is removed and the inhalation discontinued.

3. Deep, rapid, regular breathing with audible stertor, flushed appearance, fixed globes, and absence of corneal reflex indicate the presence of surgical anæsthesia.

4. The very rapidity which makes ethyl chloride so satisfactory an anæsthetic, constitutes its chief danger, fatal effects occurring before warning is given of the approach of danger.

Dangers.

It would seem that death from ethyl chloride resembles very closely that already discussed with reference to chloroform. A fatal result probably depends upon over-dose causing

syncope, which circumstance may either result from respiratory depression, or actually precede it.

Contra-indications.

1. Subjects of chronic alcoholism.
2. Heavy smokers — probably owing to presence of weak action of the heart.
3. Patients with morbid conditions causing stenosis of the air-passages.
4. Patients with heart disease.

After-Effects.

Headache, nausea, and vomiting usually follow a full dose of ethyl chloride. The vomiting may be very severe in character, and be delayed for some hours.

Great depression is a well-marked sequela.

Mixtures Containing Ethyl Chloride.

Somnoform is a mixture of ethyl chloride (60 per cent), methyl chloride (35 per cent), and ethyl bromide (5 per cent).

Narcotile is stated to be a mixture of ethyl chloride, methyl chloride, and ether.

AFTER-TREATMENT OF PATIENTS.

The effects of nitrous oxide are usually so transient that no special precautions are

required. The patient must rest in the chair until all feelings of giddiness and sickness have passed off. Should faintness ensue, spt. ammon. aromat. (30 to 60 min. in water) should be administered, and the horizontal posture enforced. After ether, more attention is required. Directly the operation is completed, the head should be held forward to allow of the escape of blood, etc. Coughing and spitting are to be encouraged, and swallowing forbidden. The alternation of periods of consciousness and unconsciousness (see page 6) will be apparent, and must be borne in mind; the former increase in length till recovery is complete. Recovery can be hastened by rubbing the face (especially the lips) with a towel. Profuse sweating is frequent, hence the patient must be guarded against the risk of chill. Manifestations of hysteria and intoxication should be met with firmness and gentleness. Pallor and faintness usually indicate the onset of vomiting, and are relieved by its occurrence.

The vomiting which is met with after ether, administered for dental operations, does not call for any special treatment. As a rule it is nothing more than the effort on the part of the stomach to remove material swallowed during or immediately after the operation, and as such is salutary rather than otherwise. The administration of sips of hot water has the

double effect of washing out the stomach and of staying the sickness. I make it a rule to advise that the first article of " nourishment " given be a cup of *hot* tea (without much milk), and if this be vomited, another should be given shortly after. In rare cases, usually after closed ether, especially if a second application of the anæsthetic has been necessary, vomiting may continue for some hours. Abstention from food, the maintenance of the horizontal position, and the administration of hot drinks, will suffice to relieve symptoms. If the operation takes place at home, it is advisable to send the patient to bed for a few hours ; if it be performed in a dental surgery, rest for an hour or so in the recumbent posture should be insisted upon.

CHAPTER VII.

ANÆSTHETIC EMERGENCIES AND THEIR TREATMENT.

THE subject divides itself into three parts: (*A*). *The causation of danger to life*; (*B*). *The prevention of danger to life*; (*C*). *The method of treatment of emergencies.*

A.—THE CAUSATION OF DANGER.

In the preceding chapters I have, in describing the different anæsthetic agents and their action on the human organism, alluded to the various dangers which may beset the individual who undergoes anæsthetization. The subject is of such vital importance that it may be well to recapitulate the dangers before describing measures for their prevention and treatment.

Risk to life during the administration of an anæsthetic occurs either through (*I*) *The Respiration*, or (*II*) *The Circulation.* Failure of one or other of these great systems may depend upon:—

1. The action of the anæsthetic itself;
2. The state of the patient; or
3. The association of some intercurrent circumstance, avoidable or unavoidable.

I.—THE RESPIRATORY SYSTEM.

1. *Primary respiratory embarrassment or failure.*—For purposes of description we must divide the respiratory system into two parts: (i) The periphery—or respiratory apparatus; (ii) The centre—or nervous control.

i. *Peripheral disturbance* with the due performance of the respiratory act may occur:—

From without, due to (*a*) tonic spasm; (*b*) faulty position altering the anatomical arrangement of the parts; (*c*) constriction from tight apparel; (*d*) an overloaded stomach; (*e*) tumours compressing the trachea—goitre or aneurysm.

From within, due to (*a*) growths of the tongue and naso-pharynx; (*b*) foreign material entering the larynx or bronchus, such as mucus, vomit, blood, pus, artificial dentures, teeth, broken forceps, props, sponges; (*c*) swelling of soft parts due to the action of the drug employed.

ii. *The centre.*—Embarrassment or failure may result from: (*a*) over-dose pure and simple; (*b*) anæmia resulting from fall of blood-pressure; (*c*) reflex action.

A condition difficult of classification is one occasionally observed where the whole apparatus is at fault. The respiratory cycle is seemingly carried on (presumably by the extraordinary muscles of respiration) without interchange of

lung gases taking place, i.e., the patient breathes without respiring.

2. *Secondary respiratory failure,* consequent upon circulatory failure.

II.—THE CIRCULATORY SYSTEM.

Failure of the circulation may result from :—

1. Respiratory embarrassment or failure due to any of the causative factors already enumerated.

2. Over-dose. Where the general condition of the patient is unsatisfactory, this may occur during the administration of nitrous oxide, ether, chloroform, or ethyl chloride, and even in healthy people may occur with the two last-named drugs.

3. Circumstances connected with the operation, such as : (*a*) fear ; (*b*) a second administration of nitrous oxide ; (*c*) reflex inhibition due to operation during incomplete anæsthesia.

B.—THE PREVENTION OF DANGER.

1. Selection of Cases.

A consideration of this subject reveals a flaw in the argument that dental surgeons are as well fitted to administer anæsthetics as are their medical brethren.

Apart from the question of skill in the administration, the dental surgeon is undoubtedly at

a disadvantage when the advisability of employing general anæsthesia in a given case is the point at issue. The difficulty, however, is not an insurmountable one, and the dental student will go far towards bridging the gap if he will grasp the many opportunities which are offered daily in the anæsthetic room of the hospital, to auscultate and otherwise examine all cases previous to the induction of anæsthesia, and to discuss with the demonstrators of anæsthetics the conditions found.

2. **Choice of an Anæsthetic.**

It cannot sufficiently be insisted that :—

i. Dental operations are never questions of life and death, and that the safest anæsthetic is the one which in all cases must be selected.

ii. The dangers of nitrous oxide (with the exception of a second administration) are practically only those of asphyxia, the production of which should be honoured in the breach.

iii. Ether in a healthy subject rarely if ever causes primary circulatory failure.

iv. Chloroform is a powerful heart depressant, and it is probable that ethyl chloride has a similar action.

3. **Preparation of the Patient.**

4. **Care during the Operation.**

5. **Details in Administration.**

C.—THE TREATMENT OF EMERGENCIES.

I.—RESPIRATION.

Should respiratory failure threaten in the course of an administration, it is important to recognize the precise cause, and to carry out treatment as follows :—

(*A*). *For obstruction* :—

1. Withdrawal of the anæsthetic.
2. Alteration of posture.
3. Insertion of a gag.
4. Drawing forward of the tongue.
5. Cleaning out of the upper air-passages by swabbing or introducing the finger.

If one or more of these measures fail to restore respiration, it may be necessary to perform laryngotomy or tracheotomy.

Laryngotomy.—Inapplicable to persons under the age of thirteen. The head is extended over a sand-bag or hard cushion and kept fixed, with the chin in the middle line. The larynx should be steadied. A vertical median incision $1\frac{1}{4}$ in. long is made through the skin over the lower part of the thyroid cartilage, the crico-thyroid space, and the cricoid cartilage. The fascia is divided, and the sterno-thyroid and crico-thyroid muscles are separated. A horizontal incision is made through the crico-thyroid membrane just above the cricoid cartilage, and a tube inserted.

As an alternative, the crico-thyroid membrane may be divided vertically and the incision extended downwards through the cricoid cartilage if necessary.

Tracheotomy.—There are two operations, the high and the low. The former is preferable, and will alone be described.

N.B.—The isthmus of the thyroid gland lies across the second and third (sometimes the fourth) tracheal rings in the adult, but is somewhat higher in children.

The preliminaries detailed under laryngotomy having been observed, a skin incision 1 to 1½ in. long is made, having its upper extremity at the upper border of the cricoid cartilage.

The sterno-hyoid and sterno-thyroid muscles having been separated, the posterior layer of the cervical fascia is divided and the trachea exposed. The isthmus of the thyroid is displaced downwards and held by a blunt hook. A sharp hook is inserted below the cricoid cartilage and held steadily in the middle line.

A mesial incision is made vertically upwards through the first three tracheal rings, and a tube inserted.

(*B*). *For failure of central origin*, i.e., overdose, anæmia, or reflex inhibition :—

1. Rub the lips ;
2. Press on the chest during expiration.

If these measures fail—

3. Artificial respiration must be proceeded with forthwith.

Artificial Respiration.—The patient is placed in the horizontal position, with the head low and the shoulders raised. The tongue should be drawn forward and if necessary tied in that position.

Sylvester's Method.—The surgeon, standing behind the patient's head, grasps the forearms just below the elbows, and draws the arms upwards, outwards, and backwards, with a sweeping movement, crossing the forearms over the top of the head. The flexed arms are then brought slowly downwards, forwards, and inwards, till the arms and elbows are pressed firmly against the body, with the elbows four or five inches from the sternum.

These movements should be repeated some fifteen times a minute and should be persevered in so long as any hope of life remains.

Howard's Method.—Applicable to cases where manipulation of the arms is contra-indicated.

The patient is placed on the floor in the supine position, hands above the head, and the epigastric region raised above the level of the rest of the body. The surgeon, kneeling astride the patient's hips, the balls of his thumbs resting on either side of the epigastrium, grasps with his fingers the adjacent sides of the chest. Using the knees as a pivot, he throws all his

weight forward on his hands, and at the same time squeezes the waist between them, gradually increasing the pressure. He then suddenly lets go with a final push, and springs back to his original position, remaining erect on his knees for a space. These movements should be repeated twelve to fifteen times per minute.

Laborde's Method.—Invaluable with children, and applicable to adults when Sylvester's or Howard's methods are contra-indicated. A gag is inserted and the tongue drawn forward and held in that position for two seconds ; it is then allowed to recede into the mouth. The movements should be repeated about fifteen times per minute.

Schäfer's Method.—For this, the most recent method introduced, are claimed certain advantages over the older methods. No preliminaries are required. The patient is placed in the prone position with the head turned to one side. The tongue falls forward naturally. The surgeon, kneeling at one side, places the palms of his hands on the lower ribs, the thumbs almost touching over the loins. Leaning forward, he applies gradually increasing pressure downwards. Then drawing back his body the pressure is rapidly relaxed. These movements in rhythmic cycle should be performed twelve to fifteen times a minute.

(*C*). *When associated with cardiac failure.*—Inversion should also be practised.

II.—CIRCULATION.

1. *Failure of circulation due to over-dosage.* The treatment consists of: (*a*) artificial respiration; (*b*) inversion; (*c*) heart massage—externally through the diaphragm; (*d*) the hypodermic administration of ether, brandy, strychnine or caffeine, alone or in combination; (*e*) inhalation of amyl nitrite.

2. *Failure of circulation due to embarrassed respiration.*—The condition must be treated according to the rules laid down for respiratory failure.

3. *Syncope due to circumstances connected with the operation.*—When due to fear the ordinary treatment for syncope should be adopted, and great caution should be exercised in deciding as to the advisability of recommencing the administration.

The caution against a second administration of nitrous oxide has already been given. Operation during incomplete anæsthesia is to be rigorously avoided.

In conclusion, it should be remembered that recovery of circulatory tone lost secondarily to respiratory failure is more likely to occur with ether than with chloroform anæsthesia.

CHAPTER VIII.

ANALGESIA.

By JOHN BOLAM, L.D.S. Edin.

In dealing with the section of "Dental Anæsthetics" which it is proposed to study herein, the term "analgesia" is employed advisedly throughout, as being more accurate than the older name of "local anæsthesia." Anæsthesia in its accepted sense means absence of all sensibility, and the term local anæsthesia—used to indicate the abolition of sensibility to pain in a certain region only—is obviously incorrect. Analgesia, on the other hand, is defined as absence of sensibility to pain, and describes accurately and concisely the result required of analgesic agents, namely, temporary paralysis of the sensory nerve-endings to painful impressions. It is not proposed to deal in this chapter with pressure anæsthesia, nor with the many applications of local analgesics to minor dental operations which will suggest themselves to the reader: its scope is limited to a consideration of the production of true analgesia of the portions of the maxilla and mandible which bear teeth, with a view to the painless removal of the latter.

The subject is one which, with varying periods of notoriety, enviable and otherwise, has steadily gained ground in favour and importance during the past decade. At the time of writing, analgesia—purged of the errors of its earlier fanaticisms, and with its advantages, limitations, and dangers alike viewed and weighed calmly and dispassionately by the modern scientific dental practitioner—can claim a recognized place in the field of operative dental surgery.

Nevertheless it must be clearly understood that the following pages carry no brief for analgesia as against anæsthesia. Each has its own sphere of operation, and though in the single case of anæsthesia by nitrous oxide, some degree of comparison is possible and may even be of value, the main object in view is to put concisely before the student of analgesia the resources at his command, to describe how they may be best controlled and employed, and to demonstrate the results which he may anticipate from their use.

Methods of producing dental analgesia may be classified as follows: (I) *Analgesia by refrigeration*, i.e., by the application of volatile substances capable of producing freezing; and (II) *Analgesia by endermic injection of drugs.*

I. THE REFRIGERATION METHOD.

"Freezing the gum," to use the popular

term, might well be called the dental sheet-anchor of the domestic servant, with whom its use seems to be a tradition, but the sphere of this method in dental surgery is, nowadays, limited. At the same time it is sufficiently useful in certain cases to warrant a short resumé of the subject.

Agents employed.—The chief substances which have been from time to time introduced as local refrigerants are ether, methyl chloride, ethyl chloride, and certain mixtures of the last two, e.g., anæsthyl, coryl, etc. Of these, ethyl chloride may be said to hold the field. Ether, as being less effectual, and liable to induce after-pain and sloughing, and methyl chloride, on account of the difficulty and danger of storage and application, have fallen into disfavour.

Mixtures may be dismissed as having no real advantages over their constituents. Ethyl chloride is obtained in glass cylinders, generally of a capacity of 60 c.c., drawn out at one end and provided with an extremely fine capillary opening guarded by a screw cap or spring catch.

Method of application.—The area to be operated upon is packed off from the rest of the mouth and the throat with cotton-wool. The surface of the gum is then dried, and on to it is projected in a downward stream a fine jet

of ethyl chloride. The correct distance of the nozzle from the site of operation is variously stated as being from six to twelve inches. In practice it is attained when the ethyl chloride does not run down the gum in a liquid form but evaporates immediately. Both sides of the gum are treated until they have become white and frozen. The induction occupies as a rule from four to five minutes, at the end of which time it behoves the surgeon to operate speedily.

Analgesia by the foregoing method is superficial in character—really only inhibiting the pain induced in the gums by the application of the forceps to the tooth. It is also transient, and is applicable to only a limited class of cases.

Indications and contra-indications.—Freezing agents may be used for dental analgesia :—

1. In patients for whom the use of cocaine or its allies is contra-indicated.

2. In patients whose gums are soft, hæmorrhagic, hypertrophied, or showing a tendency to become stripped from the loosened teeth.

3. In cases of advanced caries with fistula and alveolar abscess.

4. In those cases of frequent occurrence where a number of partially absorbed and loosened roots or teeth require extraction.

Freezing agents should not be used for dental analgesia :—

1. In young children, nervous or hysterical subjects, nor in patients suffering from dyspnœa or nasal obstruction.

2. If the pulp of the tooth, or of adjacent teeth, is sensitive to thermal changes.

3. For difficult extractions necessitating time ; for the extraction of posterior teeth in general, and all lower molars in particular, especially if there be any tendency to salivation.

II. THE INFILTRATION METHOD.

Apparatus.—The apparatus required for the induction of analgesia by infiltration is simple, consisting of (1) a syringe and needles, and (2) accessories—such as test tubes, and containing and apportioning vessels used for mixing solutions and for purposes of sterilization.

The Syringe.—The form and construction of the type of syringe commonly employed in dental analgesia is familiar and requires no detailed description. In construction and arrangement of parts it is similar to the ordinary hypodermic syringe ; it is, however, larger, more heavily and strongly made, and has a special feature in the attachment to the base of the barrel, or armature, of two projecting lugs of solid metal used as a fulcrum by the middle and index fingers when injecting. The piston (which is often of the type known as "extension," containing a telescopic portion,

which may be unscrewed by the operator as the syringe is emptied, thus preserving the original length and leverage) is graduated and has a large and solid head.

Any one of the many outfits specially adapted and recommended for dental analgesia may be employed, but in making a selection the following qualities should be insisted upon :—

1. The syringe should be capable of being easily taken to pieces and put together again.

2. Parts should be sterilizable by boiling.

3. The piston should be of the extension type, and graduated in minims.

4. The syringe should be capable of holding from 40 to 50 minims ($2\frac{1}{2}$ to 3 c.c.), and possess a glass barrel through which the solution can be seen.

5. Syringes with point section and needle in one piece should not be employed.

Needles.—Detachable steel needles with soft metal heads—to be fixed to the point section by means of a long or short hub—should be used. Aseptic needles of this type, supplied in sterilized glass tubes, are now obtainable at a small cost, and a new one may thus be used for each case.

Agents employed.—Under this heading will be noted :—

1. Cocaine and its substitutes, their properties and actions, with a comparative statement

of the strength, efficiency, and toxicity of each.

2. A brief review of analgesic mixtures, and the advisability of their use.

3. The different forms in which analgesic agents may be obtained.

COCAINE.

Cocaine, in the form of its neutral salt cocaine hydrochloride, is the typical agent of the class of analgesics. The alkaloid cocaine is obtained from the leaves of Erythroxylon coca, a shrub indigenous to Peru and Bolivia. Its discovery is variously attributed to Gardeke, 1855, Maclagan, 1857, and Niemann, 1860; but no doubt attaches to the fact that its analgesic properties were first demonstrated by Karl Koeller, of Vienna, at the Congress of German oculists at Heidelberg, in 1884.

Cocaine Hydrochloride is a crystalline salt, with bitterish taste and neutral reaction. It is soluble one part in 0·4 part of water, 2·6 parts of alcohol, in glycerin, but not in either fats or oils. Its solutions are unstable, cannot be boiled without decomposition, and are apt eventually to become cloudy from the growth of fungi. To counteract this, an addition of boric or salicylic acid to the solution is often made, but the necessity may be obviated by the use of freshly prepared sterile solutions.

Cocaine hydrochloride is incompatible with borax, carbolic acid, ammonium carbonate, and all chlorides of mercury.

Action of Cocaine.

I. *Local.*—

When the drug is locally applied there occur depression of the sensory nerve-endings and consequent analgesia of the affected area, together with constriction of the arterioles and contraction of the tissues.

II. *General.*—

1. **Primary Action.**—The first effect of the drug is stimulative, as evidenced by :—

Central Nervous System.—Descending stimulations of the cerebral cortex, the respiratory and vasomotor centres in the medulla, and the reflex centres in the spinal cord.

Muscular System.—Increased irritability and stimulation of voluntary muscle.

Circulatory System.—Increase in arterial pressure, accelerated action of the heart, and peripheral contraction of arterioles due partly to muscular action and partly to vasomotor stimulation.

Respiratory System.—Increase in rate and depth, due to stimulation of its centre.

2. **Secondary Action.**—The secondary or toxic effects of a large dose of cocaine consist of marked depression following in each instance

the area of initial stimulation. Thus there occur (1) depression and disturbance of the cerebral functions, (2) depression of the medulla and spinal cord, (3) feeble respiratory action, (4) depression of vasomotor and reflex actions, (5) muscular inco-ordination, (6) depression of the vascular system with fall in the blood-pressure, due partly to dilatation of arterioles consequent on decreased vasomotor control and muscular relaxation, partly to direct cardiac depression.

The visible symptoms attendant on the foregoing secondary effects of cocaine are, with slight variations, fairly constant and well defined. They will be considered, together with their treatment, in the section dealing with "Complications and Sequelæ."

The dose of cocaine is $\frac{1}{20}$ to $\frac{1}{2}$ gr., and no solution containing more than 1 per cent should be employed. The resultant analgesia is deep, constant, quickly induced, and readily persists for ten minutes or more. It is sometimes possible to operate immediately, though two to four minutes' interval, according to circumstances, is generally allowed.

Substitutes for Cocaine.

1. **Eucaine Hydrochloride B.** (Beta-eucaine) is a synthetic alkaloid allied to cocaine. It occurs in small white crystals soluble one in

twenty-eight parts of water, giving a neutral solution which is stable, keeps well, and may be boiled.

Local Action.—Eucaine does not cause either constriction of arterioles or contraction of tissues.

General Action.—Similar to cocaine, but its systemic action is more stimulative, and its toxic effects are estimated to be only one-fourth.

The dose is $\frac{1}{10}$ to $\frac{1}{2}$ gr., and solutions of a strength not exceeding 2 per cent may be employed. Analgesia is slow of induction and probably not so intense as that obtained by the use of cocaine, but persists for some time.

2. **Novocain,** discovered in 1905, is a synthetic salt in the form of colourless crystals. It is soluble one in one part of water to form a neutral solution, which is stable and may be boiled.

Local Action.—Novocain is said to be non-irritating, and is a vasodilator.

General Action.—Novocain is said to affect neither circulation nor respiration, and its toxicity is estimated as one-seventh that of cocaine.

The dose is $\frac{1}{5}$ to 1 gr., and a 2 per cent solution may be used. The analgesia obtained is slow of induction but powerful, being practically equal to that of cocaine, but it is more transient.

3. **Alypin** (Bayer).—Is a crystalline synthetic salt, soluble one in one part of water and four parts of 90 per cent alcohol. Its solutions are neutral and may be boiled. Strong solutions keep well, though weak ones may become cloudy.

Action.—Similar to that of cocaine, but much less toxic. The dose is $\frac{1}{20}$ to $\frac{1}{2}$ gr., and 2 per cent solutions may be used. Analgesia is satisfactory and very quickly induced.

4. **Tropacocaine Hydrochloride** (Merck) is the salt of an alkaloid obtained from Java coca, but is also prepared synthetically. It is soluble freely in water and alcohol. The solutions are stable and may be kept indefinitely.

Local Action.—This salt does not cause constriction of arterioles.

General Action.—It is said to be less toxic than cocaine—respiration not being affected by large doses, and the circulatory system only slightly so. The dose is $\frac{1}{4}$ to 1 gr., and solutions up to 3 per cent have been used. Analgesia is quick of induction, and very powerful but transitory.

5. **Stovaine.**—Is a synthetic hydrochloride, soluble readily in water, less so in alcohol and acetic ether. Solutions are slightly acid, germicidal, and may be subjected to prolonged boiling without decomposition.

Action.—Stovaine is a feeble vasodilator,

and its toxicity is rated as one-third that of cocaine. It is said to have a toxic action on the heart.

The dose is $\frac{1}{5}$ to 1 gr., and $\frac{1}{2}$ to 1 per cent solutions may be used, though some writers recommend as high as 3 to 4 per cent. The analgesia obtained is very powerful.

Acoin, Anæsthesine, Holocaine Hydrochloride, and **Nirvanin** have also found a place in the long list of local analgesics, but proved unsuitability for the purpose, or want of sufficient experimental data, debars them from further mention at the present time, though it may be said of *nirvanin* that a future is predicted for it by American writers. It is freely soluble to form neutral solutions possessing germicidal properties, and has an estimated toxicity one-tenth that of cocaine, as much as 7 gr. having been injected at one time without complications.

Analgesics can be obtained :—

1. *In liquid form*, either (*a*) in bottles, or (*b*) in sealed sterilized glass ampoules each containing a known quantity of solution of standard percentage strength.

2. *In solid form*, for solution in water.

Of these 1 (*b*) and 2 are recommended.

ANALGESIC MIXTURES.

Of the numerous substances which have

found a place in analgesic mixtures, adrenalin alone demands consideration.

Adrenalin Chloride is the salt of an active principle, adrenalin (otherwise known as suprarenin and hemisine), obtained from the suprarenal gland of the ox or sheep. It is a heart stimulant and a powerful local vasoconstrictor. In virtue of the latter action its combination with cocaine and other analgesics has the advantage of lessening the amount of blood in the injected area, retarding the absorption of the analgesic and thus diminishing the toxic and enhancing the analgesic effects.

It is doubtful, however, if these advantages are not counterbalanced by the tendency to extensive sloughing of the gum tissues following on the injection of adrenalin. Such a result is due to local gangrene consequent on the duration and violence of its vasoconstrictor action.

Adrenalin is chiefly employed in the form of a 1 per cent solution of the chloride in normal saline, with the addition of 5 per cent of chloretone as a preservative, but other forms such as hemisine and suprarenin borate are in use.

Selection.—In this matter, the student of analgesia will naturally prefer to use his own discretion. He will, however, be wise not to pin his faith to any one drug, but to employ and familiarize himself with such as he thinks will cover his sphere of work, however large

their number may be. As a general rule, cocaine, eucaine, and novocain will suffice for all cases, and a careful study of the properties and actions of each, in conjunction with a knowledge of the selection of individual cases, will enable the operator to choose aright.

STERILIZATION.

It seems hardly necessary to impress upon the student the importance of asepsis throughout every phase of the process about to be described, but a brief commentary upon sterilization will not be out of place here.

1. *The area of operation.*—Though not possible in many cases—a large proportion of extractions by this method being of the "casual" class—previous sterilization of the entire oral cavity by means of mouth washes should, whenever opportunity offers, be attempted before extraction. Failing this, the immediate area of operation should be rendered as aseptic as time and circumstances will permit by direct application to the part, by means of swabs, of such antiseptic agents as 2 per cent of lysol or carbolic acid, glyco-thymoline or glycerin thymolis co., liquid kolynos, and chinosol. Pure carbolic acid applied by the ball end of a plastic filling instrument to the spots selected for the needle, will ensure a sterile puncture, and at the same time, by its own analgesic action, lessen the pain.

2. *The syringe and needle.*—If the syringe be kept between operations in a special sterilizing stand such as the Bardet sterilizer, it will generally suffice to fill it with the selected antiseptic once before use. The point section with a needle taken direct from its aseptic glass tube is attached, and the contents of the syringe are expelled through it. At the end of the operation this process is repeated before returning the syringe to the sterilizer. All syringes should be taken to pieces periodically, fresh washers adjusted, and the parts boiled, and no antiseptic likely to corrode or act upon either washers or metal parts should be left in the syringe. It is best always to remove the last traces by washing out with sterile water.

If needles are used more than once they should be boiled, dried by means of absolute alcohol, and stored in a sterilized test tube closed by a plug of aseptic cotton-wool. The hub which carries the needles should also be frequently sterilized.

3. *The solution.*—Solutions should be made fresh with distilled water, or taken direct from a sterilized sealed ampoule. Whenever possible they should be boiled before use, and all vessels and mixing appliances with which the solutions come in contact must likewise be aseptic. "Bottled" solutions, though handy, are not to

be recommended unless they can be sterilized by boiling before use. Stale solutions of this type should on no account be employed.

Lastly, let us remember the important part our own hands play in the process, and be aseptic ourselves.

TECHNIQUE OF THE INJECTION.

1. *The initial puncture* is often dreaded by the patient, and if, in the opinion of the operator, the application of a drop of pure carbolic acid to the spot—as practised by some—be not sufficient to ensure its being painless, pressure upon the gum for a minute or two with a pledget of cotton-wool soaked in the analgesic solution will achieve the desired result.

In the case of labial and buccal punctures and those on the lingual side of mandibular teeth, the needle should be entered at the muco-periosteal junction, which is situated a little to the gum edge of the centre of an imaginary line drawn from the gum margin to the apex of the root. On the lingual side of maxillary teeth the needle should be inserted about $\frac{1}{8}$ in. more or less—according to the arch of the palate and consequent thickness of tissue overlying the root—from the neck of the tooth, and pressed upwards in the shortest line towards the apex.

In all cases the line of penetration of the

needle must be kept in the thickness of the gum. If it be inserted too deeply, the external wall of the alveolar plate will preclude the passage of fluid, while if the point be turned outwards and reach too near the surface a bleb will result.

2. *Continuance of the injection.*—As the infiltration proceeds, a good deal of resistance to the exhaustion of the syringe will be experienced, particularly if the tissues be healthy, and a gradually extending patch of blanched and tense gum will appear. The injection should now be continued by means of slow and steady pressure upon the piston until the required area is obtained.

3. *Number of punctures.*—Opinions differ as to the number of punctures required, and by different authorities it is variously given as from one to four or more. One cannot state any hard and fast rule as to this, but a minimum of two punctures in the case of anterior teeth and premolars, one for each root in maxillary molars, and one on either side of each root in mandibular molars, is indicated.

The author confesses to a fairly frequent use of multiple punctures, but each case will of course be treated on its merits, according to the discretion of the practitioner. At the same time, while a minimum is to be aimed at as liable to produce less hæmorrhage and afford

a better chance of healing, the primary consideration is an efficient analgesia.

4. *Quantity of solution to be injected.*—This is variable, and depends upon (*a*) the drug employed; (*b*) the percentage strength of the solution; and (*c*) the required area of analgesia. Forty to fifty minims of standard strength is generally ample, but if it be desired to infiltrate a large area, more of a weaker solution may be used, provided that the safe dose of the drug employed be not exceeded.

5. *Difficulties of injection.*

i. Difficulties due to morbid conditions of the gums. In cases of spongy, hyperæmic, and hypertrophied gums, and those showing a tendency to become stripped from their alveolar border, the characteristic anæmia is often hard to induce.

The use of the finest of needles, together with the addition of adrenalin to the solution, will usually be effectual.

ii. Difficulties associated with position of the teeth. (*a*) In cases of single teeth standing alone, where the surrounding aum is dense and fibrous; (*b*) In the case of the six anterior teeth of the mandible where the tissues covering the alveolar ridge are very thin; and (*c*) In the region of the mandibular

third and sometimes second molars (owing to the thickness and prominence of the alveolus), infiltration is often difficult and the resulting analgesia unsatisfactory.

In order to meet these difficulties: (*a*) Four, or if necessary a ring of punctures should be made round the tooth; (*b*) The employment of nitrous oxide is here distinctly indicated; (*c*) Injection should be made by the use of a curved needle parallel to the mucous membrane and alveolar border.

iii. A special note must be made of the difficulties presented by the presence of *fistula* and *alveolar abscess*. In the one case the gum, riddled with sinuses and fistulous openings, often refuses to retain the fluid; while in the other, not only is injection into the pus area useless and painful, but it is fraught with extreme risk of toxic symptoms, owing to rapid absorption of the injected drug.

No attempt should be made to inject the affected areas, but the sphere of analgesia must be extended so as to surround and include them.

6. *Precautions*.—Care should be taken (*a*) To avoid undue pressure on the tissues of the mouth with the left hand, which sometimes follows

involuntarily on the great force exerted by the right hand; (*b*) To apply the pressure equally, keeping the syringe barrel and the needle in a straight line, lest the latter be fractured and damage to the soft tissue result; (*c*) To avoid leakage of the solution into the cavity of the mouth, and particularly on to the soft tissues beneath the tongue, whence its active constituent would be rapidly absorbed.

7. *When to operate.*—The estimated periods of two to four minutes for cocaine, about five minutes for eucaine, and a full five minutes for novocain, have been found within certain limits to be fairly constant.

In the case of the less familiar analgesics, experience alone can provide the information.

Selection of Cases.—Should be governed by

1. *The age, temperament, and attitude of the individual patient.*—Children, especially below the age of six, and at all ages when nervous and excitable, are bad subjects for analgesia. They are so often intimidated by the early stages of the process, i.e., the initial puncture, etc., that even if the analgesia be perfect they will deny the fact. Unless the operator has a thorough personal knowledge of the temperament of the child, anæsthesia is in most of the cases to be preferred. The same applies to the class of hysterical and neurotic women, though by such patients the use of an analgesic

is often insisted upon. Here, and also in other patients who adopt this attitude, the method can usually be carried to a successful issue, since an admixture of faith and pride will generally constrain them to assure us at the conclusion that they felt nothing. Finally, for those patients who have a horror of anæsthesia as involving loss of consciousness, and in those rare cases where anæsthesia by nitrous oxide has been an entire or partial failure, analgesia is indicated.

2. *The physical and organic condition of the patient, idiosyncrasy, etc.*—Analgesia by means of cocaine (and other analgesics in varying degrees) is contra-indicated in the presence of :—

Debility, either recent (resulting from drain on the system due to the presence of morbid conditions of the mouth, or from sleeplessness due to odontalgia), or constitutional and of long standing.

Neurasthenia.

Anæmia.

Cardiac affections, particularly aortic disease and fatty changes.

Diseases of the respiratory tract, with associated dyspnœa.

Pregnancy in its later stages.

Lactation.

Idiosyncrasy. In a certain percentage of cases the injection of even a small dose of an

analgesic produces the symptoms characteristic of cocaine poisoning. Unhappily the operator usually has to find this out for himself at the cost of painful experience, but if there be a history of such idiosyncrasy, the use of cocaine or its substitutes should be avoided.

3. *The nature of the operation*, i.e., the number and position of the teeth to be extracted and their condition, and that of their environment.

The production of analgesia, at one sitting, corresponding to an area of more than three or four teeth, is to be condemned, especially if the teeth are in different parts of the mouth. Only a certain amount of fluid may be safely injected, and if the area be very widely distributed or very large—including ten or twelve teeth or even more (and one sometimes hears of such cases)—then either the solution must be over-diluted or the infiltration imperfectly performed.

Anterior teeth with fairly solid roots, and mandibular third molars, usually give, from the nature of their surroundings, imperfect results with analgesia.

At the same time, in all difficult single extractions, such as lower third molars, displaced and impacted teeth, badly broken-down and buried roots which would require the expenditure of so much time and care as otherwise to necessitate the patient's undergoing the

ordeal of a prolonged anæsthesia, analgesia even if not quite perfect is to be preferred.

Infiltration into suppurative areas is contra-indicated.

Complications and Sequelæ.

1. *Local.*—
   i. *Hæmorrhage* in any degree is rare; when present it is generally due to violence of reaction from the induced anæmia of the capillary circulation.
   ii. *Sloughing of the gum* is not uncommon, and is due either to sepsis or localized gangrene associated with the use of adrenalin.
2. *General.*—These result from:
   i. Faulty position, i.e., the upright instead of the reclining;
   ii. Fear on the part of the patient;
   iii. Toxic effects due to absorption of the injected drug into the system.

Symptoms of Cocaine Poisoning.

Early.—Patient nervous and agitated, may complain of room being stuffy; slight headache, perhaps some tingling in lower extremities, slight pallor, and blueness of lips. Pulse and respiration strong and rapid.

Intermediate.—Headache, dizziness, nausea, increasing pallor with cold perspiration,

muscular tremors, especially of lower extremities, and increased disturbance of circulation and respiration—the latter presenting a condition which has been aptly described as " air hunger."

Later.—Face deathly pale and covered with beads of cold perspiration, mucus membranes anæmic, pupils dilated or unequal, increased nausea, muscular inco-ordination, pulse rapid, feeble, and sometimes intermittent or almost imperceptible, respiration slow, shallow, and irregular.

Ultimate.—Vomiting, incoherence of speech, muscular spasms, epileptiform convulsions, unconsciousness, paralysis of circulation and respiration. Collapse. Coma, and death by asphyxia.

Treatment.

Early.—The recumbent position; clothes loosened; plenty of fresh air; sal volatile or brandy by the mouth.

Intermediate.—Cover up and keep extremities warm; strong coffee with brandy internally; ether or ammonia by inhalation or internally ($\frac{1}{4}$ to 1 dr.); flick front of the chest with towels soaked in cold water; ether subcutaneously (20 to 30 minims).

Later.—Injectio strychninæ nitratis hypodermica (2 to 6 minims) subcutaneously; artificial respiration.

*

Stimulant remedies should be given as undiluted as is consistent with safety, in order that thus their additional irritant action may cause an efficient reflex stimulation. As soon as recovery is established sufficiently to allow of swallowing, black coffee should be given.

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